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Teaching in Higher Education

ISSN: 1356-2517 (Print) 1470-1294 (Online) Journal homepage: http://www.tandfonline.com/loi/cthe20

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To cite this article: Hanna Kienzler & Carolyn Fontanesi (2016): Learning through inquiry: a Global Health Hackathon, Teaching in Higher Education

To link to this article: http://dx.doi.org/10.1080/13562517.2016.1221805

Published online: 23 Sep 2016.

TEACHING IN HIGHER EDUCATION, 2016
http://dx.doi.org/10.1080/13562517.2016.1221805

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Learning through inquiry: a Global Health Hackathon

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ABSTRACT

This article offers a description and critical evaluation of a novel method for inquiry-based learning (IBL) directed at undergraduate students: a Global Health Hackathon. The hackathon was piloted as part of an 'Introduction to Global Health' undergraduate course in order to enable students to gain *and* create knowledge about specific global health-related challenges and, simultaneously, to acquire tangible and transferable skills. We provide a critical evaluation of our practice by drawing on relevant academic literature concerned with IBL, course material to describe the hackathon and its related components and outputs, and student evaluations to reflect on the overall module experience. We conclude by sharing reflections and recommendations of necessary measures required to institutionalize IBL in a more sustainable manner in higher education institutions.

ARTICLE HISTORY
Received 11 June 2015
Accepted 28 July 2016

KEYWORDS
Inquiry-based learning; transferable skills; undergraduate; hackathon; global health; knowledge translation and exchange

Increasingly, teaching staff in higher education institutions are encouraged to promote student-centered learning and to build stronger links between teaching and disciplinary research. This expectation is designed to foster a culture that allows students 'to take a research-based approach to their lifelong educational development' (Spronken Smith and Walker 2010, 724). Such active learning has been linked to students' enhancement of research competence, development of transferable skills, and better chances for securing graduate employment (Mason, Williams, and Cranmer 2009). However, less information is available regarding methods for introducing students to the world of research, helping them succeed when confronted with challenging research problems, and teaching transferable skills in discipline-specific contexts.

In order to contribute to this nascent field, in our roles as lecturer (first author) and graduate teaching assistant (second author), we took the decision to follow and evaluate an inquiry-based learning (IBL) approach in our 'Introduction to Global Health' undergraduate course, which was offered by a social science department at a major UK university. We hypothesized that IBL as a pedagogical technique would allow students to gain *and* create knowledge about specific global health-related challenges and, simultaneously,

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to acquire tangible and transferable skills. Specifically, we gave IBL a chance by organizing our first Global Health Hackathon with financial support granted by the university's teaching fund.

Hackathons originated in the IT community as computing marathons where programmers, project managers, and graphic and interface designers collaborated intensively on software projects to design the next 'killer app' over one or two labor intensive days (Leckart 2012). They are now increasingly being employed in educational (London School of Economics and Political Science, New York University, Massachusetts Institute of Technology), creative (BBC News Hack, Music Hack Day), corporate (Facebook), and government (the UK's National Hack the Government Day) sectors. During such events, enthusiastic individuals come together, form working teams around challenges and, in collaboration, find innovative solutions from scratch. At the end of the hackathon, the solutions are formally presented and evaluated based on whether they work, are good ideas with a suitable problem/solution fit, show a well-designed experience and execution, and have the 'wow factor' (Brenner 2011).

As hackathons have been shown to facilitate collaborative learning through inquiry (Leckart 2012), we decided to pilot this novel approach in our Introduction to Global Health course with a focus on finding simple technological solutions to common global health problems. The stated goal was to assist in closing the 'knowledge-to-action' gap in global health through innovative Knowledge Translation and Exchange (KTE) methods. Thereby, we aimed to support students in their continuing professional development by teaching them how to gain and create knowledge through independent inquiry, to expand their knowledge of global health, and to equip them with transferable skills.

In this article we offer a description and critical evaluation of the hackathon as a method for IBL in hopes of providing our colleagues with practical information for the organization of similar events. First, we provide a reflective overview of the literature concerned with IBL. Subsequently, we briefly outline the course and follow with a detailed description and evaluation of our Global Health Hackathon. To conclude, we share reflections and recommendations of necessary measures required to institutionalize IBL in a more sustainable manner in higher education institutions.

The promotion of IBL in higher education

IBL emphasizes the importance of students performing investigative work that prioritizes question-driven rather than topic-driven activities (Aditomo et al. 2011). It has been variously interpreted; Spronken-Smith et al. (2011) characterize IBL as approaches to teaching 'in which learning is stimulated by a question or issue, learning is based on constructing new knowledge and understanding, the teacher's role is one of a facilitator, and there is a move toward self-directed learning' (15). Similarly, Oliver (2008) proposes that IBL refers to approaches in which 'some form of problem or task serves as catalyst for student engagement and participation […], learning comes as a consequence of the information processing that occurs as students work to explore the problem setting and to seek a solution' (288). Both these quotes highlight the importance of students acquiring new transferable skills, being involved in goal-oriented teamwork and engaging with tasks that stimulate creativity, higher order thinking, and reflection.

IBL is based on constructivist educational theory that encapsulates the notion that 'what the learner has to *do* is to create knowledge' (Biggs and Tang 2003, 13; see also Levy and Petrulis 2011, italics in original). Learning how to create knowledge is understood as social practice and, as such, intrinsically connected to 'the social meanings that are produced collectively in a given setting' (Jones 2009, 93). That is, rather than perceiving learning as individual attainment of knowledge and skills, the focus is on 'communities of practice' (Jones 2009) within which attributes are made meaningful, taught and applied. To foster independent learning, a process called 'scaffolding' is recommended during which the initial support provided by the teacher tapers off over time while profound and independent learning increases simultaneously (Spronken Smith and Walker 2010).[1]

The report of the Boyer Commission (1998) was among the first to forcefully advocate for achieving independent, lifelong learning by tasking undergraduate students in the US to create knowledge, rather than to simply listen to lectures. The report recommends making research-based learning the standard, constructing an inquiry-based freshman year, building on that freshman foundation, removing barriers to interdisciplinary education, linking communication skills and course work, using information technology creatively, culminating with a capstone experience, educating graduate students as apprentice teachers, changing faculty reward systems, and cultivating a sense of community. A decade later, the Higher Education Academy in the UK similarly called for new forms of research-based teaching for undergraduate students so as 'to cultivate awareness of research careers, to train students in research skills for employment, and to sustain the advantages of a research-teaching connection in a mass or universal system' (Ramsden 2008, 10–11).

Reviews of ongoing IBL approaches in higher education have identified a number of techniques that have since been developed. Aditomo et al. (2011) categorize eight forms of IBL tasks as scholarly research, simplified research, literature-based inquiry, discussion-based inquiry, applied research, simulated applied research, enactment of practice, and role-playing. Studies investigating students' perceptions of and attitudes towards moving from a 'learning paradigm' to a 'discovery paradigm' have largely established that learners acquire knowledge most effectively when engaged in their own research projects. Regularly highlighted benefits include increased confidence, intellectual advancement through operating in the mode of researcher, development of critical thinking and problem-solving skills, and understanding scientific mechanisms and underpinnings, both conceptually and in practice (Brew and Jewell 2011; Healey et al. 2010; Justice et al. 2007; Spronken Smith and Walker 2010; Visser Wijnveen et al. 2010).

However, IBL has not gone without criticism. A literature review by Kirschner, Sweller, and Clark (2006) shows that minimally guided instruction is unlikely to result in effective learning as no reference is made to the 'characteristics of working memory, long-term memory, or the intricate relations between them' (76). Moreover, it is argued that such approaches may have negative effects when students obtain 'misconceptions or incomplete or disorganized knowledge' (84). Instead, strong instructional guidance is considered to be more effective when students receive full explanations of concepts and procedures in addition to particular learning strategies that help them to absorb and process the knowledge. Nevertheless, the authors recognize that IBL can be successful when students obtain 'prerequisite knowledge and undergo some prior structured experience' (82).

In our own approach to IBL we take this well-evidenced critique seriously. Specifically, we combined the hackathon as an approach to IBL with sufficiently structured guidance so

as to introduce students to concepts, theoretical frameworks, and relevant background knowledge; actively guided and provided constructive feedback during processes of knowledge acquisition; and, together with the students, critically reflected on their findings vis-à-vis previously introduced concepts and theoretical frameworks. We believe that such a combined approach is a promising way forward in allowing students to develop skills in self-reflection, critical thinking, independent inquiry, and research, taking responsibility for their own learning, and intellectual growth and maturity (Spronken Smith and Walker 2010).

IBL in the classroom: a Global Health Hackathon

Our Introduction to Global Health undergraduate course introduces students to the key concepts and debates in global health, investigates the knowledge-to-action gap in global health interventions and uses case studies to illuminate health inequalities and the political, economic, social, and structural forces that perpetuate these disparities. The key educational aims are to introduce students to major concepts and deliberations regarding how to define global health and how it might be secured. We introduce them to the knowledge-to-action gap in different fields of global health and to the strategies that aim to close it; provide them with the skills needed to critically evaluate such initiatives and to identify the role of key stakeholders in shaping them; demonstrate the value of interdisciplinary approaches to global health; and provide insights into the use of particular methodological and epistemological tools in the production of global health research. To achieve these learning outcomes, students are required to attend lectures and seminars, study assigned readings at home, and submit research papers.

While this format lends itself well to more traditional teacher-centered approaches that focus on knowledge transmission, we found that it left little room for students to independently construct knowledge and develop new insights in the field of global health. In order to create a more dynamic approach to teaching and learning and allow students to do their own inquiries into complex global health problems, we carried out a Global Health Hackathon that was held 10 weeks into the semester (14 February 2014). Following this event, we asked students to critically engage with their research outputs. For their midterm examination (24 February 2014), they each created infographics to display their innovative solutions visually with the help of new software. Infographics allow for complex messages to be expressed through images in clear and fast to grasp ways (Adams 2011) by integrating three important elements: (1) visual elements consisting of color-coding, graphics, and reference icons; (2) content elements such as time frames, statistics, and references; and (3) knowledge elements. Including such an assignment allowed us to further enhance transferable skills particularly with the view that infographics are increasingly used in different fields such as government, the corporate sector, the NGO community, medicine, engineering, and research and development. The infographics were later printed, displayed, and presented by the students during a formal poster-presentation, which formed part of the department's public seminar series devoted to social science research on health-related matters. Finally, each student submitted a graded essay (24 March 2014) describing, analyzing, and critically reflecting on their research outputs by embedding them into wider global health discourses, employing the concepts that were presented throughout the term.

Twenty-two third-year study abroad students (18 female; 4 male) from the US attended the course.[2] Half of them (11) were enrolled in science-related majors, while only four were enrolled in the social sciences and humanities at their home universities.[3] Curious to learn about their motivations for taking the 'Introduction to Global Health' course, we requested at the beginning of the first session, that they write a short note outlining their motivations and what they hoped to learn about global health. Their motivations were diverse but included some common features such as a desire to learn more about how globalization is connected to health inequities in and between countries, gain a better understanding of how social and political determinants affect health, strive to become better informed clinicians in the future, and learn about health systems beyond those in the US. Their learning goals encompassed acquiring knowledge about pressing global health issues, possible solutions to global health problems, how global health is connected to other socioeconomic factors impacting people's lives, the health gaps between and within countries, and how to get engaged as a professional in this field.

As none of the students reported prior knowledge about global health, we designed and planned learning activities that were more transmission-based at the beginning of the term to provide a solid overview of the field. Based on this, we gradually moved toward independent learning through inquiry and research following a scaffolding approach. In order to monitor teaching and learning effectiveness, we incorporated a number of evaluation methods throughout the term. In the following, we will describe these different elements and their alignment by focusing on our hackathon in order to provide information on how we introduced students to IBL, how our approach supported students' self-efficacy in improving their coping skills when confronted with challenges, and the kinds of transferable skills that were developed in this process.

Preparations for the Global Health Hackathon

Preparing students for the Global Health Hackathon took a participatory approach that involved them as collaborators in the project from the onset of the semester, not just as novice participants, but also as leaders and decision makers. Through this active approach to learning, we hoped that students would become more proficient with the use of technology, engage in interdisciplinary collaboration, and be innovative and output-oriented. The lecturer (first author) included one of our department's Master of Science students (second author) as co-applicant on the grant application submitted to the university's teaching fund, and later as teaching assistant to help with the conceptualization and realization of the hackathon. She was responsible for working in collaboration with an undergraduate teaching assistant enrolled in the course to help with the organization of the event by recruiting postgraduate students from other departments as volunteers, developing training materials, creating a blog featuring the hackathon and its results, and organizing an infographics exhibition. The rationale was to provide postgraduate students and teaching assistants with the opportunity to translate their theoretical knowledge into practice by working in collaboration with undergraduate students and within a limited time frame. Additionally, the first author wanted them to gain tutoring and organizational skills while learning how to merge academic knowledge with business experience in order to enhance their employability and enterprise skills.

Together with the undergraduate students, we developed the following sequence in order to prepare for the hackathon: Four weeks before the hackathon took place, the undergraduate students formed working groups of five to six members. Their first task was to formulate a well-structured hackathon challenge to address during the event. This turned out to be more difficult than anticipated, as the students' first challenge-formulations produced extremely broad and rather unmanageable research problems. After an internal discussion regarding the feasibility of the students' proposals, we opened the discussion up to the class, and together developed a three-stepped approach.

First, students were required to individually formulate a well-structured challenge related to a concrete problem concerning KTE in a specific region of the world, and email it to us for feedback prior to the next session. Specifically, students had to identify a particular field in global health in which knowledge is translated and exchanged, locate 'blockages' that hamper the transmission and implementation of knowledge pertinent to improving health, and highlight elements of this problem and the ways they are related to other structural issues in the identified field. Second, during the following session, students had to present their challenges to their working groups in order to discuss them critically. They then had to come to a consensus regarding which two challenges to pick and further investigate through the rest of the week. Third, the session before the hackathon was conceptualized as a two-hour workshop during which each group discussed their two selected challenges by focusing on the following questions: *Who* is your target population? *What* is the KTE related challenge and its components? *Where* does the target population interact with the problem? *When* does the problem occur and why? *How* does the problem unfold and affect the target population? The purpose of this exercise was to further substantiate the hackathon challenges and increase their feasibility. Once they properly grasped the challenges, each team had to select one to address at the hackathon. This last step turned out to be a source of tension among some groups and was addressed through unmediated negotiations resulting in a compromise. Thus, the developed hackathon challenges consisted of (1) resource allocation problems in the medical field that hamper the effective sharing of supplies between hospitals and clinics in South Africa; (2) the neglect of HPV vaccination in resource-poor settings like Uganda; (3) the lack of locally relevant evidence on autism and its treatment; and (4) sexual education in the US that bridges the gap between authoritarian and peer-to-peer approaches. Following the workshop, students studied their selected problems in-depth by engaging with academic literature, reports, and relevant websites. In the meantime, we distributed the selected challenges to the postgraduate volunteers, lecturers in our department with expertise in global health and two professional digital designers. We expected them to reflect on the challenges and recommend tools and software to the students for the day of the hackathon.

Hacking global health

The hackathon was an exciting and inspiring full-day event. After the workstations were set up and the agenda of the day introduced, the hackathon started at nine o'clock. Throughout the morning and early afternoon students gathered in their work groups where they invited postgraduate volunteers, subject-specific experts, and digital designers to their particular group at will in order to further refine their respective challenge and its components and discuss ways in which their hackathon problem could be improved

through an innovative solution. They began to formulate possible recommendations that could be made to solve or improve the situation, to outline the pathways that would have to be created in order that the possible solution would, in reality, solve the problem; and to think about whether or not the recommendations would have the capacity to change the flow of knowledge. There was an immense buzz in the room as participants discussed and refined their challenges and began to think on the spot about possible solutions.

While food and drinks were provided throughout the day, no official break was scheduled, allowing teams to work independently and at their own pace, embracing the momentum of the event. Over the course of the afternoon, the teams agreed on a possible solution for their challenge and set out to refine its components and to gain a better understanding of how each component would add to solving the problem. Moreover, they started to experiment with different types of software and built prototypes or actual functioning technical solutions with the help of the volunteers. The goal was not to have a fully functioning tool but a solid outline that would not require much more tweaking before becoming 'reality'. At five o'clock in the evening, each group had to formally present their challenge and respective solutions.

The outcomes were impressive and included (1) a platform that would enable hospitals and clinics in South Africa to record their inventory and prioritize specific local needs to facilitate exchange, while at the same time giving the Ministry of Health and private donors access to this information to circumvent resource waste in some sectors and inadequate supplies in others. (2) A new HPV vaccination program that would reach girls in schools as well as girls who dropped out early through free texting services, a buddy program, and an interactive website that includes vital educational material, a registration and location platform, and a tool for appointment reminders. (3) A web-based platform that offers global information about autism and a questionnaire that would allow community health workers rather than researchers or clinicians to gather locally relevant data on autism to expand the evidence base through surveys and testimonies. (4) A sexual education website that bridges peer-to-peer and more authoritarian approaches currently employed in the US through a needs assessment and research component, safe and anonymous spaces for information gathering and sharing, and interactive components between users of the platform through 'show' and 'tell' components as well as content trending.

We were amazed by their well-prepared presentations for which they had used prezi (a presentation software) to outline their hackathon problem, justified its importance, provided relevant background, and presented their innovative solution which included the demonstration of already functioning features. The presentations were both professionally delivered and provided insight into how much students had learned over a very short period of time about particular diseases, challenges related to providing adequate healthcare in particular settings, benefits, and limits of current knowledge exchange strategies employed by global health interventionists, and the targeted use of new and interactive technologies and communication methods that could enhance information flow and thereby improve clinical practice. While able to provide insight into key concepts, debates, and problems in global health through lectures and readings, we could have never transmitted such in-depth and complex knowledge solely through a traditional lecture-based approach. Instead, students were now able to apply concepts learned during the lectures to their newly gained

knowledge and reflect upon their innovations critically as they produced infographics and later their final essays.

Evaluation of the course

To evaluate the hackathon and overall course experience we employed a number of strategies. (1) On the university's online educational portal a message board for discussion was created that allowed students to exchange ideas and opinions with other participants. (2) An anonymous midterm in-class feedback form was distributed following the hackathon to gain insight into student satisfaction and learning and to modify teaching practices if necessary. The form included a mix of free-response and quantitative questions. (3) A similar anonymous in-class feedback form was distributed at the end of the semester requesting students to provide feedback on the course as a whole. (4) Students were encouraged to meet with us during office hours to discuss the course, share ideas for the assignments, and talk about any difficulties that were affecting their work. Here, we will report and compare the results of the formally elicited midterm and final course evaluations as we did not record more informal feedback systematically. Nevertheless, it is crucial to note that the informal feedback influenced the organization of the hackathon and our teaching as students shared interesting ideas and made important suggestions for improvements throughout the course.

In total 21 students filled out the midterm and 15 the final questionnaire. As fewer students turned up for the last day of class, the survey results are not fully comparable. Nevertheless, insightful patterns emerged: Table 1 shows student ratings regarding enjoyment, learning, and reading material, rating their answers on a Likert-type scale from 1 (not a lot) to 10 (a great deal). The results indicate that students had an overall positive learning experience.

In order to evaluate the preparation for assignments and fulfillment of the course aims and objectives, students rated their answers on another Likert-type scale from (1) very well, (2) quite well, (3) not very well, and (4) not at all. Moreover, they had the possibility to provide written feedback for each of the categories.

The results of the midterm evaluation (Table 2) show that students were satisfied with the 'direct instructional guidance' (Kirschner, Sweller, and Clark 2006, 75) on the key concepts and debates, theories, interdisciplinary approaches related to knowledge and exchange in global health. However, fewer felt well prepared for the hackathon and the infographics assignment. The reason for this might have been that they had not received their grades for the infographic at that point and were unsure about how well they had performed.

When comparing the midterm evaluation results with the final evaluation (Table 3), it appears that students continued to be satisfied with the lecture and seminar content focusing on global health and the different initiatives that aim to secure it, the persistent knowledge to

Table 1. Enjoyment, learning, reading materials (numbers in parentheses refer to the midterm evaluation results).

	1	2	3	4	5	6	7	8	9	10
How much did you enjoy the course?						(2) 1	(9) 2	(4) 5	(3) 4	(3) 3
How much did you learn from this course?				(2)	(2)	(1) 2	(8) 4	(4) 3	(1) 1	(4) 5
How difficult did you find the reading material?		1	1	(4) 1	(9) 6	(4) 3	(1) 2	(3)		1

Table 2. Midterm evaluation: preparation and aims/objective.

	1	2	3	4
How well did the course prepare you for the hackathon?	3	15	3	0
How well did the course prepare you for the infographic?	1	11	7	2
How well did the course fulfill the following aims/objectives so far? To introduce students to key concepts and debates around knowledge transfer and exchange in global health	14	7	0	0
How well did the course fulfill the following aims/objectives so far? To approach knowledge transfer and exchange from an interdisciplinary angle by reviewing the publications of work various fields/ disciplines	11	9	1	0
How well did the course fulfill the following aims/objectives so far? To develop an understanding of theories of and approaches related to the key concepts related to KTE in global health	9	11	1	0

action gap in the field as well as critical and interdisciplinary perspectives. Strikingly, however, they felt much better prepared for the assignment. We assume that their self-confidence was boosted when they received overall very good marks for their hackathon outcomes and infographics and thus reconsidered the level of preparation they had received.

The overwhelmingly positive reaction to the delivery of course content was also reflected in the written feedback, which included two additional categories: 'Three good things about this course were […]' and 'Three things about the course which could be improved were […]' In the following, we will present the written feedback based on thematic analysis and by focusing on the topics that received most attention by the students.[4]

The 'content and content delivery' of the course received most attention and resulted in exclusively positive feedback in both midterm and final evaluations. One student wrote for example, 'good background given on global health and enjoyed the close look at certain diseases' while others highlighted the 'current research base' of the lectures, the interesting material, and the wide range of topics covered. Another component that received almost as much feedback was 'preparation for assignments'. The comments provided for the midterm evaluation were mostly positive with regards to the hackathon, in that students stated that they felt well supported, enjoyed working in groups, and thought that it was a great learning opportunity. However, the responses related to the infographic assignment were mostly negative, reflecting students' insecurity with having to use unfamiliar tools and technologies and their own work. Typical responses were 'I was really unsure of how to create an infographic. Even though you provided us with examples I felt as if I didn't have the technology/tools to create something as advanced as the one you sent us' or 'I am just a little uneasy because I don't exactly know what the standard is for an infographic. I have never done one before so I can't really tell if mine is good or not.'

Table 3. Final evaluation: preparation and aims/objectives.

	1	2	3	4
How well did the course prepare you for the assignment?	5	9	1	
How well did the course fulfill the following: To introduce students to key concepts and debates regarding what global health is and how it might be secured	11	4		
How well did the course fulfill the following: To introduce students to the knowledge to action gap in different fields in global health and strategies that aim to close it?	9	5	1	
How well did the course fulfill the following: To provide students with the skills to critically evaluate such initiatives (strategies to close the know-do-gap) and to identify the role of key stakeholders in shaping them	9	5	1	
How well did the course fulfill the following: To demonstrate the value of interdisciplinary approaches to global health	9	6		

Interestingly, the results of the final evaluation reflected more balanced comments, which may be indicative of students' increased self-confidence. Many of them reported that they enjoyed the assignments, praising them for being creative and different from what they were used to, allowing them to think about global health in a myriad of ways, and giving them the opportunity to employ new skills. A typical response was, 'the assignments were very well explained and a good measure of our course'. However, almost as many comments were provided with regards to the wish for more preparation and guidance, and to explore a greater diversity of topics rather than focusing only on the hackathon challenge. One student recommended, 'more strict guidelines for the hackathon and more software teaching for infographics' and someone else noted, 'I enjoyed the hackathon and the group work with it. I also enjoyed the infographic assignment. I would have liked a bit more preparation and guidance to aid in the experience.' We probably overestimated the technological savvy of some of the students, assuming that they would be able to familiarize themselves with the software faster and more independently than they did. Consequently, we consider the feedback as extremely valuable and will make sure to set more time aside to provide students with additional training and, thereby, allow independent learning to happen at a slower pace.

Other topics that generated a great number of responses included the first author's 'teaching style', which was described positively in both evaluations highlighting that she presented the material in an organized, interesting, and interactive way, that she took enough time to meet with students individually, that she answered questions thoroughly inside and outside the classroom, and that she showed great patience. As one student expressed, 'you were a great teacher and taught at a level which everyone could learn and relate to'. The required course readings sparked more varied comments. It was positively noted that they were enjoyable and pertinent while more critical reflections indicated that the readings could have been more approachable.

The topics 'hackathon' and 'group work' with peers and the volunteers garnered numerous comments indicating that the scaled development of a community of learners was indeed valued. Typical comments were: 'the idea of a hackathon was novel and a creative way to learn'; 'I enjoyed the hackathon and infographics – they were different from the typical papers and exams and allowed for a lot of creativity'; and 'hackathon and infographic gave opportunities to use new skills and work with others'. While the midterm evaluation included some hesitant comments wishing for more structure and guidance, these were not reflected in the final evaluation. Instead, constructive critique was offered suggesting, for instance, the involvement of the volunteers not only during the hackathon but also in some of the seminar sessions throughout the course. This is an interesting suggestion as it would allow for the community of learners to become more consolidated and reach beyond the classroom.

Less frequent comments referred to the 'lectures' and 'learning'. Several students reflected that they learned a lot from the lectures and that the guest lecturers were well chosen and their presentations very interesting and informative. A student wrote, 'everything was new to me and I was enthralled the whole time!', while another wrote, 'I am not a "science person" but I felt comfortable in this class because it approached global health from so many disciplines.' One student would have preferred more lectures while someone else suggested including additional guest lectures to be exposed to a wider range of teaching styles. The comments in both the midterm and final evaluations

made apparent that lectures continue to play an important role in students' learning and that they can be enjoyable and stimulating. Thus, we argue that a move toward 'IBL' should not deprive students from lectures, but rather offer a balanced mix between lectures, seminars, and more independent IBL.

An analysis of the comments shows that more 'traditional' aspects of learning and teaching were highlighted by the students while crucial IBL concepts like 'new forms of assessment', 'creativity', 'interdisciplinarity', 'skills', etc. received a lot less commentary. Yet, despite the shortage of comments with regards to these newer teaching and learning techniques, this does not mean that they did not play an important role in the students' learning and development of self-efficacy. It would be interesting to further investigate how such newer techniques interact with more traditional ones and, in combination, enhance students' learning and self-confidence in the long-term.

Reflections and recommendations

Our aim of piloting the Global Health Hackathon was to cultivate an interactive, inquiry-driven environment in which students could engage with the lecture material and new technologies in practical ways. Through an approach that combined direct instructional guidance with IBL it was possible for undergraduates to become proficient in critical thinking (reflected in their self-assessment, their final essays and in-class discussions) and, with the vital support of postgraduate students, in 'twenty-first-century skills' including on-the-spot thinking, presentation skills, working with different software, creating prototypes for websites, and disseminating their work. We consider these not only to be important academic skills but also resume and career-building experiences.

Such an inquiry-based approach required us to consider teaching and learning together with assessment strategies to ensure the suitable alignment of learning outcomes, teaching, and learning activities (Biggs and Tang 2003; The Higher Education Academy 2012). Thereby, we aimed to allow students to develop relatively high levels of competency in their newly won skills as competency itself has been linked to in-depth understanding of discipline-specific knowledge and methods, mastery of transferable skills, and an adequate dose of self-efficacy (Knight and Yorke 2003; Rosenberg, Heimler, and Morote 2012; Turner 2014). In fact, research highlights that students who believe in their own abilities seek more challenging projects and persevere longer when faced with difficult tasks that do not lend themselves to straightforward solutions (Turner 2014). The experience of successful performance, in turn, has been related to raised 'efficacy expectations' connected to increased self-esteem (Lane, Lane, and Kyprianou 2004) and to a decrease in feelings of stress, anxiety, and depression (Bandura 1986; Yi and Hwang 2003; Zimmerman 2000).

While we put a lot of thought into sequencing the various elements to ensure an appropriate alignment with the learning outcomes, students made important recommendations for future improvements. Firstly, approaches that use communication skills, information technology, and software creatively need to have a solid training component inbuilt. Such training would allow students to become more confident in the use of technology and, thereby, to focus more on content and tangible outcomes. Secondly, in order to consolidate the bonding experience between students and graduate volunteers, working groups could remain active throughout the semester to further develop newly won skills. This would expose undergraduate students to more interdisciplinary learning while graduate

students could gain additional experience as apprentice teachers and further improve their team-working and organizational skills. Thirdly, it is important to choose course readings and other information materials not only with a focus on whether they are up-to-date and aligned with a particular session, but also by connecting them with the assignments more effectively.

Besides aiming to improve our own teaching along the lines mentioned above, it is important to continue to provide students with a space in which they feel safe, have control over their actions, enjoy working together, and perceive that their work is making a difference (Turner 2014). Yi and Hwang (2003) advise that teachers should generate environments 'where conceiving one's ability as a fixed entity is discouraged, accepting challenging goals is encouraged, and making errors while learning is regarded as normative part of skill acquisition' (446).

We hope that our outline of and reflections about the use of hackathons as a pedagogical technique will help other teachers to introduce similar IBL activities in their classrooms. At the same time, we recognize that the challenge remains of how to make inquiry-based approaches to learning part of our department's and university's education strategy. First of all, it would be vital that we begin to perceive undergraduate students as co-developers of our teaching and research, and engage them in our line of work beyond the classroom. This, in turn, would require that colleagues within the department and across the college promote a culture allowing for inquiry-based and interdisciplinary teaching and learning. At the same time, it would be necessary to take existing structural barriers into account such as the lack of funding for teaching-related activities provided by the college and other academic funding bodies or the emphasis on research and publications dictated by the Research Excellence Framework. 'Constructive alignment' has to happen inside the classroom as well as at college and even national levels if IBL is to be instituted in a sustainable manner in higher education.

Notes

1. An example for successful scaffolding is the international student cooperation project, teaching students from Germany and the francophone part of Switzerland intercultural communication techniques and project development. The course commenced with a lecture-based approach providing theoretical foundations and moved increasingly toward inquiry-based learning by first applying Kayes et al.'s team-learning approach and then following Kolb's intercultural team approach that required students to form intercultural teams and design projects from scratch (Frisch and Kristahn 2015).
2. The course was only open to study abroad students as our undergraduate degree had not yet been officially launched.
3. Science disciplines included biology, neuroscience, mathematics, biomedical science, psychology, and biochemistry; social science and humanities disciplines included English, American studies, and political science.
4. The themes are organized according to the number of times they were mentioned starting with the ones that received most of the attention by the students.

Acknowledgements

We would like to acknowledge the financial support we received from the College Teaching Fund, King's College London, to carry out the hackathon and to print and exhibit the infographics. We are

very grateful to our undergraduate teaching assistant Kara Luthi who liaised with her peers, designed a blog and helped with preparing and carrying out the event. We would also like to thank Professor Parry Bronwyn and Richard Palmer for their support of the project and the practical advice they offered along the way. Finally, we would like to thank our colleagues and graduate students who generously supported the event with their expertise (Dr Laurie Corna, Dr Scott Vrecko, Cakar Cemre, Cameron Spence, and Liana Marinescu) and our students who participated with enthusiasm in the course and, particularly, during the hackathon.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the College Teaching Fund (CTF) 2013, King's College London.

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